**Appendix A:**
**Copy of U.S. Provisional Application for Patent**
**U.S. Serial No. 60/182,766 Filed February 16, 2000**

# METHOD OF CONTROLLING VEHICLE ACCESS

## Zipcar
## Vehicle: Access, Board Computer, Transmission

Figure 1

The company will provide access to the cars with a proximity card based on the Phillips MIFARE chip. The card reader will be located behind the windscreen and be connected to the board computer. The board computer will compare the ID of the card with the ID of the currently active reservation and will initiate to unlock the doors if they are the same.

The board computer will contain an E2 memory chip and some rudimentary logic that will:

- Compare the ID from the card reader with the ID of the active reservation and drive the door lock mechanism,
- Compare the PIN from the keyboard with the PIN from the active reservation and un-interrupt the starter,
- Keep track of odometer reading,
- Perform a series of queries designed to extend a reservation from within the car, indicate the condition of the car, and send out a warning if customer will be late.

The board computer will also have a user interface with keypad and display. (also see appendix 1)

We will perform the transmission of data from and to the board computer through a GSM-General Packet Radio Service (GPRS), which is currently under development by Omnipoint Technology. Zipcar will be one of the first companies to integrate this new digital service into an application.

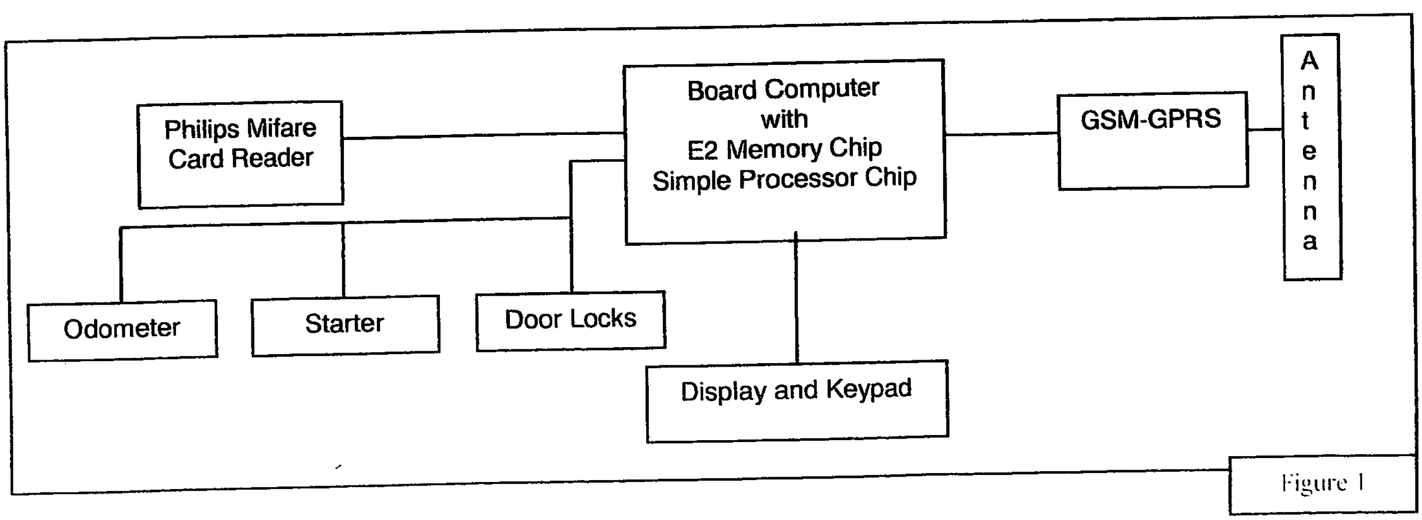


Figure 1

## Web-Based Administration

Figure 2

- The Zipcar server will securely connect all software applications to the Internet.
- Readings from the cars will be send to the service provider, from there, using Internet Protocol (IP) to the Internet and the database on the Zipcar server and vice versa (see appendix 2 for sent information).
- Clients will use the Internet to make their reservations.
- Billing will be done directly through debit cards or via email.
- New clients will apply directly on the web-site allowing for the data to be entered into the database electronically.

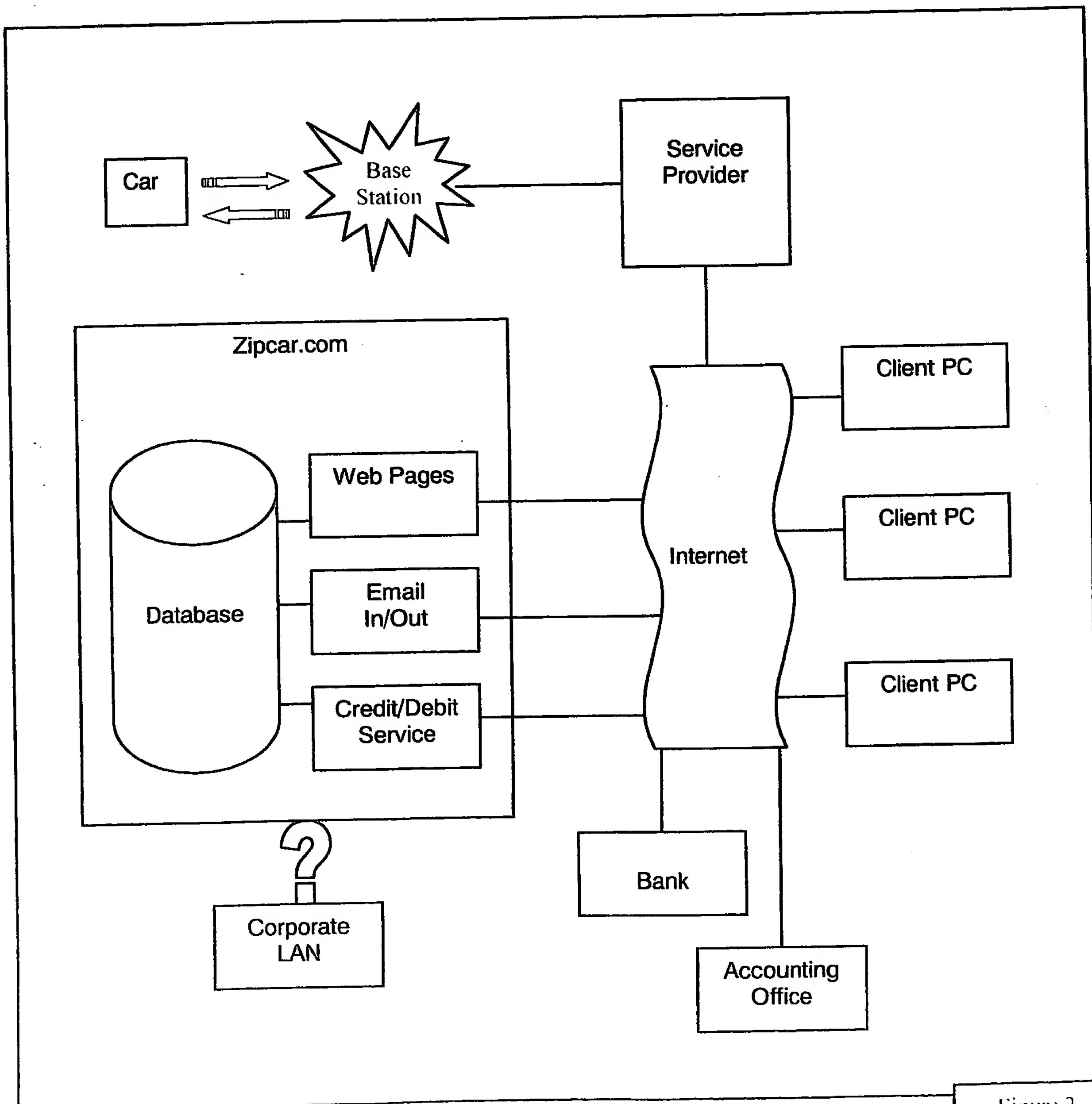


Figure 2



44

**Reservation and billing Systems:**

Data transmitted wirelessly from car to server falls into the following types of data and is used as follows:

**Odometer reading and start/stop times as logged in/out by user:**

- Compiles the bill [components of billing overall are refundable security deposit; annual fee; hourly and per mile rates based on chosen plan. Also, rates for work-day rental, and 24-hr rentals supercede the hourly/mile rates.]
- updates user activity statements viewable by each member
- Reports for analysis [difference between actual use and reserved time, etc.]

**Notification that car is "OK/Not OK"** [reporting state of cleanliness or car accident]

- Triggers an email or phone call to person currently using the vehicle to followup on with details of the report so action can be taken.

## Request to extend reservation

- Updates the reservation schedule

ONLINE RESERVATION SYSTEM

- Enables members to choose the city, car location, and time of reservation online from a schedule displaying car reservation status for the week. Users can change any parameters and see real-time display of the status of their request.
- Members see status of upcoming reservations [ability to cancel or change this as well] and their activity statement for current and past months.



45

Appendix 1, Specifications for Vehicle Systems

| Entry | Board Computer (BC) | Server – Car Transmission | Hardware requirement |
|---|---|---|---|
| | | Server sends info on reservations to the cars as they come in, whenever car is in it's spot. | Internet connection for server. GPRS modem for car. |
| | Board computer stores reservation info (times and IDs) | | BC needs processor and memory chip. |
| Proximity Card[1]; Reader sends ID # to board computer. | Board computer compares card and reservation ID and if ID checks out[2] initiates opening of the door. Denies opening the door if ID doesn't check out. | | Hardwire from BC to card reader. |
| | Screen query: PIN # | | Keypad and small screen, or touch screen, enter button; |
| | PIN # is entered: Goto screen with 4 options | | |
| | Screen with 4 options: (A) start session (B) reservation extension query (C) late status report (D) end session | | |
| | (A) PIN belongs to reserved customer, board computer enables ignition, grabs odometer reading and time and sends it to server. | send data packet off to server | Hardwire to starter; |
| | Car Status o.k.? "yes" / "no" | sent "o.k." or "not o.k." off to server[3] | Keypad with yes/no buttons or touch screen; |
| | Your reservation is x to y N minutes available after y Would you like to extend? -> "yes" "no" | | ditto |
| | if "no" | | Hardwire to odometer |
| | if "yes" go to (B) | | |
| | (B) Your reservation is x to y N minutes available after y How many additional minutes would you like? Enter in "30", "60", "90" Goto screen with 4 options | send data packet off to server | |
| | (C) Please type in the # of minutes you will be late.[4] Goto screen with 4 options | send data packet off to server[5] | some button that could signal infinity or touch screen |
| | (D) End of session? "Yes" / "No" | | |
| | If "yes", disable ignition, grab odometer reading and time. Last query: car status o.k.? "yes" / "no" | send data packet with odometer reading and time to server | |
| | If "no" leave everything as is and goto screen with 4 options. | | |
| | | | |

[1] card has a unique #, all cards open all doors card unidentifiable—no logo
[2] When the car is reserved it opens for the customer who has the reservation only. It also opens to any ZipCar user if the car is currently not reserved.
[3] Triggers email to customer with complaints-form.
[4] "x" # of minutes, or "infinite" # of minutes -> accident or break-down.
[5] Triggers phone call to next customer. Triggers find a replacement car for location.



46

Appendix 2

Zipcar Car-server Message Contents

1.Add/delete reservation message: when the server sends the reservation information to the car, it will send the following:

type=add or delete reservation
user ID
PIN
pickup date/time
return date/time
reservation ID
vehicleID
current date/time

2.Usage message: when the car sends usage records back to the server, it will send the following:

type=pickup or return
userID
date/time
mileage
status code(s)
reservation ID
vehicleID

3.Reservation extension request message: when the user requests an extension to the reservation, the car will send the following:

type=extend reservation
userID
date/time
reservationID
vehicleID
extension duration

4.Reservation extension acknowledgement message: the server will respond to the Reservation extension request message with a message containing the following:

type=acknowledge reservation extension
ok/denied flag
reservationID
vehicleID
current date/time
userID
new return date/time

5.Power up message: when the car first recovers from a power failure, it will send the following:

type=request for all pending reservations
vehicleID

This will trigger a flood of Add Reservation messages back from the server.



47

Appendix 3, MIFARE Information

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home Select & Go... go find

NEWSROOM

- Newsroom
- Newsletters & Articles
- In focus
- Subscribe to eNews
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**1997-05-01 , *MIFARE NEWS***
**volume - , issue 6 , article nr 8**

## MIFARE® - The Architecture Platform for Contactless smart cards

**With close to 50,000 read/write devices and 10 million MIFARE® chips in use in more than fourty operational installations world-wide, Philips Semiconductors is leading the Smart Card Industry into the contactless era.**

In the late 80s the need for a fast, easy to use and secure smart card was concentrated in Public Transport. The idea behind the concept, however, was to have one single card to be used for several applications at the same time. The result of all these efforts was the MIFARE® Technology, which in comparison to contact technology was developed at a breathtaking pace.

Keeping in mind the fundamental requirements to the system, it was considered very important to create an upward compatible MIFARE® Hardware Architecture. This continuously expanding modular architecture covers products for any service provider wishing to apply contactless smart card technology to their needs.

Today the MIFARE® Architecture Platform comprises a variety of compatible reader modules suitable for multi-facetted target applications as well as different types of MIFARE® card ICs. In order to keep the leading position in contactless smart card technology further developments are, of course, under way.

### MIFARE® Card ICs

The different available card ICs are tailored to allow the implementation of comprehensive smart card systems based on different types of cards which are all compatible with the MIFARE® reader infrastructure. The three MIFARE® Card IC types ranked by their functionality are:

- **MIFARE® LIGHT** designed for single application cards

such as electronic 10-trip tickets in public transport or phone cards. This optimized small memory product targeted at high volume, cost sensitive applications is also an efficient, fast and secure substitute for magnetic stripe cards currently used in applications like road toll, energy metering and similar

- The standard contactless **MIFARE®1 S50** used for complex multifunctional types of applications. With its significantly larger memory new functions and/or applications can be easily added to the card.
- **MIFARE® PLUS**, the Combi Card IC developed by Philips/Mikron, makes use of both, the contact and the contactless infrastructure.

The next generation of Philips Semiconductors' MIFARE® based contactless controller ICs is currently under development:

**MIFARE® PRO.**

This generation will comprise card ICs with a processor being able to handle both interfaces, contact and contactless, which will further increase user convenience, flexibility and security.

**MIFARE® Read/Write Modules**

The variety of read/write modules offer different read/write distances and depending on the specific needs can either be ready to plug in or require more complex integration.

The MIFARE® product range for read/write modules includes:

- The MIFARE® Core Module with a read/write distance of typically 100 mm is dedicated to applications requiring a high throughput of secure transactions in a minimum amount of time. Target applications are gate controllers in metro stations, bus terminals, EFT POS terminals or even PCs.
- The MIFARE® Serial Reader Proximity with a typical operating distance of 65 mm is the counterpart to the MIFARE® Core Module offering several serial interfaces for the communication with the host system. It is suited for terminals using control LEDs, switches or buttons for the transaction with a contactless card.
- The MIFARE® Micro Module with a typical read/write distance of 25 mm can be used for small, compact readers, handheld devices, slot or surface readers.

Typical high volume applications are on-board units for non-stop road toll, metering units or public payphones.

- The MIFARE® Serial Reader Short Range with a typical operating distance of 25 mm is based on the MIFARE® Micro Module and features an RS232 serial interface. For system integration of this reader into a specific application only basic knowledge of the MIFARE® System is required.

Based on the wide range of products already available and further innovations to be added to the MIFARE® Hardware Architecture, Philips Semiconductors is fully committed to maintain the Architecture Platform on the basis of MIFARE® beyond the year 2000.





9



51

Appendix 4, Omnipoint GPRS Information

# GPRS Strategies: Planning a Successful Adoption

## Introduction

With General Packet Radio Service (GPRS), an important step toward third-generation services, GSM operators can offer cost-effective, full-time connectivity at rates up to 115 Kbits per second. GPRS is the network technology choice for the evolution of both GSM and US standard IS-136 networks. GPRS coupled with Enhanced Data rates for Global Evolution (EDGE) will enable GSM and IS-136 operators to offer wireless multimedia IP-based services and applications at speeds up to 384 kbit/s. GPRS was designed to be added with minimal cost and disruption, but as with any new technology, a successful transition starts with careful planning and a realistic assessment of the task.

This paper offers a perspective on positioning GPRS relative to other advanced GSM offerings, describes the network modifications that GPRS requires, and explores the business and technology choices involved in a successful GPRS adoption.

## Positioning GPRS for Customers

GPRS is not the only new technology available for boosting GSM data rates, of course. High Speed Circuit Switched Data (HSCSD) was designed as a higher-speed alternative to standard GSM service and can offer data transfer speeds up to 57.6 Kbps. For the operator, HSCSD is easy to implement since it consists primarily of software upgrades with no backhaul modifications. For the end user, HSCSD helps enable such data-intensive applications as Web browsing, real-time services, and large file transfers.

While GPRS has the potential to deliver higher data rates as well, in a realistic assessment, actual rates in the near term are likely to be significantly lower than 115 Kbps. The real strength of GPRS is the ability to offer cost-effective, continuous connectivity. GPRS is optimized for "bursty" transmissions, where users would like to be connected full time but won't generate enough traffic to justify dedicated channels. Because packet technology doesn't dedicate a

circuit for each connection, operators can offer users the opportunity to stay online without incurring exorbitant airtime charges.

Given the complementary nature of the two services, the ideal situation will be to implement both technologies and promote them to customers based on application.

## GPRS AND NETWORK OPERATORS' KEY SUCCESS FACTORS

The ability to grow into the future no doubt played a key part in every operator's decision to adopt GSM. As with every planned enhancement to GSM, GPRS supports the operator's key success factors in the highly competitive wireless market:

- **Time to market.** As all operators know all too well, the market for voice and data services is becoming increasingly competitive and new entrants are able to establish themselves quickly. By bringing advanced services such as GPRS online as quickly as possible, GSM operators can continue to exploit GSM's inherent advantages for handling digital data.
- **Open platform for continued upgradability.** Similarly, GSM's philosophy of designing for the future with an open platform will help network operators and service providers respond quickly to new market demands. While GPRS does require a number of changes to the GSM network, it offers a fundamentally new kind of service while leveraging the investments already made in the basic network.
- **More users per available spectrum.** New GSM services utilize the spectrum and network resources more efficiently, resulting in more subscribers and higher revenues relative to cost. GPRS, for instance, uses network resources so efficiently operators can offer continuous connectivity at a fraction of the cost of a full-time circuit-switched connection.

## A Realistic Look at GPRS Implementation

Omnipoint Technologies has been designing and integrating wireless voice and data solutions for more than a decade, including some of the pioneering installations of GSM in North America. As both equipment designers and consulting engineers, we work closely with a variety of GSM technology leaders around the world to offer solutions ranging from industrial telemetry to enhanced location services. Our sister company, Omnipoint Communication Services, is one of the most experienced GSM operators in North America. Moreover, we continue to play an active role in the development of GSM standards, including GPRS.

This extensive hands-on experience with GSM technologies has provided a solid education in the realities of network buildouts and upgrades. GPRS and other emerging technologies offer exciting opportunities for equipment manufacturers and operators alike, but we believe a realistic assessment of the challenges inherent in any technology upgrade will help all parties involved reach their business objectives more easily.

## How GPRS Changes an Existing Network

Adding GPRS to an established GSM network involves the addition of two new support nodes and a number of other hardware and software changes throughout the network. GPRS also introduces three new network operation modes and support for three classes of mobile terminals.

### New Support Nodes

The implementation of GPRS will introduce two new nodes required for handling packet traffic:

- **The serving GPRS support node (SGSN)** is connected directly to the base station subsystem (BSS) via the Gb interface. It

controls access, tracks user locations, and performs various security functions.

- **The gateway GPRS support node (GGSN)** serves as the interconnection point for packet data networks. It is connected to the SGSN via the Gn interface, an IP backbone. The GGSN's main functions are to set up and authenticate communication with external packet networks and to route and tunnel packets to and from the SGSN.

Both of these new nodes generate billing information that identifies which external packet network was used, the amount of data transferred, the quality of service (QoS) offered, and the duration of the connection. Figure 1 shows how the new nodes fit into the GSM architecture.

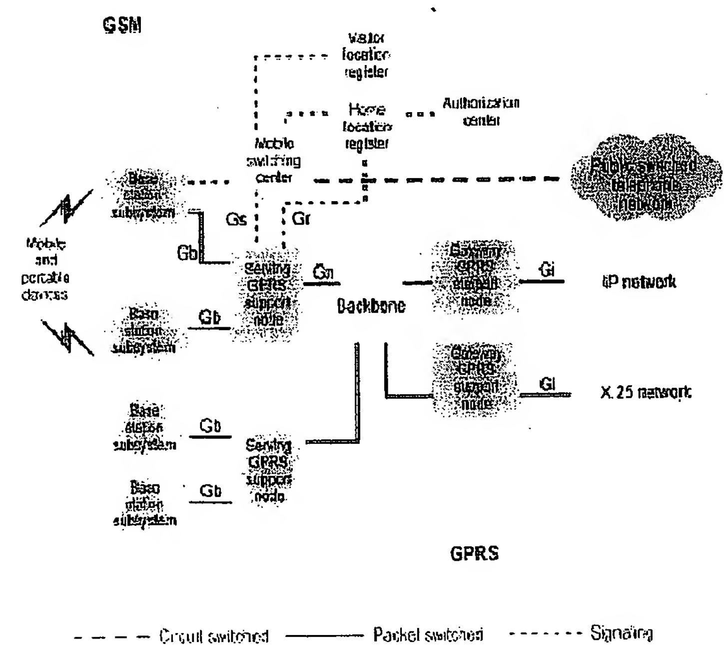


*Figure 1: GPRS additions to an existing GSM network.*

### OTHER HARDWARE AND SOFTWARE CHANGES

The base station controller (BSC) will also require hardware and software upgrades, including a packet control unit (PCU) to manage the transfer of packet data between mobile terminals and the SGSN. In addition to these hardware changes, GPRS requires a number of software changes throughout the network. For instance, the home location register (HLR), the mobile switching center (MSC) and the visitor location register (VLR) need to be upgraded to support GPRS services and to manage the new classes of mobile terminals.




15

57

## New Network Operation Modes

The GPRS/GSM network can provide coordination of paging for circuit-switched (CS) and packet-switched services. The GPRS standard defines three network operation modes based on the extent of the coordination offered:

- **Network operation mode I:** The network sends a CS paging message for a GPRS-attached mobile subscriber (MS), either on the same channel as the GPRS paging channel or on a GPRS traffic channel. The MS needs to monitor only one paging channel, and it receives CS paging messages on the packet data channel after that channel has been assigned.
- **Network operation mode II:** The network sends a CS paging message for a GPRS-attached MS on the common paging channel, and this channel is also used for GPRS paging. The MS needs to monitor only the common paging channel, but CS paging continues on this paging channel even if the MS has been assigned a packet data channel.
- **Network operation mode III:** The network sends a CS paging message for a GPRS-attached MS on the common paging channel and sends a GPRS paging message on either the GPRS paging channel (if allocated in the cell) or on the common paging channel. Therefore, an MS who wants to receive pages for both circuit-switched and packet-switched services needs to monitor both paging channels if the packet paging channel is allocated in the cell. No paging coordination is performed by the network.

The implications of these new modes will be more readily apparent later in the paper, in the discussion on connecting to the GSM network subsystem (NSS).

### NEW CLASSES OF MOBILE TERMINALS

The GPRS standard also defines three new classes of mobile terminals, based on their ability to handle circuit-switched and packet-switched data:

- **Class A terminals** support simultaneous circuit-switched and packet-switched data traffic.
- **Class B terminals** support either circuit-switched or packet-switched data traffic but can operate in only one mode at a given time.
- **Class C terminals** operate exclusively as packet-switched terminals.

With these additions in mind, we can now take a closer look at some of the key technical challenges operators are likely to face in a GPRS upgrade.

## TECHNICAL CHALLENGES IN IMPLEMENTING GPRS

As network operators upgrade to HSCSD, GPRS and on to third-generation capabilities, it's vital to understand the technological challenges these upgrades present and the impact they may have on quality of service, time to market, and overall competitiveness. This section steps through four key sets of decisions:

1. Connecting to the GSM base station subsystem
2. Connecting to the GSM network subsystem
3. Connecting to other public land mobile networks
4. Connecting to external data networks

Most of the technical questions regarding these connections can be anticipated and resolved during the planning stage. However, there are a few issues that may need refinement as the industry builds experience with GPRS.

### CONNECTING TO THE GSM BASE STATION SUBSYSTEM

The Gb interface is the connection between the new SGSN node and the existing GSM BSS, as shown previously in Figure 1. Frame relay provides the link layer mechanism for this interface. During initial roll out, when GPRS traffic is limited, multiplexing the Gb interface with the A interface over a T1 is a likely scenario. In most networks, an SGSN can be directly connected to a BSC. This topology fits the multiplexing idea nicely, since the SGSN and the MSC/VLR will most likely be colocated in initial GPRS implementations.

As GPRS traffic increases, however, there are likely to be several scenarios in which it makes sense to centralize the SGSN equipment away from existing circuit-switched NSS equipment and to use a public frame relay network between the BSS and the GPRS NSS. For instance, the packet-switch portion of the GSM service can be offered by a third-party that specializes in advanced data services. Preparing for such possible migration scenarios and analyzing their implications,

both financial and technical, should be a key step in any GPRS planning effort.

An even more critical issue is the use of flow control within the BSS GPRS protocol (BSSGP). Unfortunately, the downlink flow control was something of an afterthought and was detailed in later revisions of the GSM 08.18 standard. Experience will tell if the implementation of the recommended leaky bucket algorithm in the SGSN will be enough to differentiate between different delay classes. Another major concern is whether there are enough configuration parameters to control the method of traffic shaping within the SGSN. Again, this will be resolved with operational experience, and both issues will demand more attention when BSS and GPRS NSS equipment from different vendors are interconnected.

### Connecting to the GSM Network Subsystem

The GPRS NSS is connected to the existing GSM NSS via a number of new interfaces. The Gs interface connects the SGSN to the MSC/VLR, and the Gd interface connects the SGSN and the SMS-GMSC. The Gr and Gc interfaces connect the SGSN and the GGSN to the HLR, respectively. Operators might want to consider the option of eliminating the Gc interface completely and using the SGSN as the relay between the GGSN and the HLR. This will remove the requirement of an SS7 interface in the GGSN and let operators construct the GGSN as a pure IP gateway. (The SGSN, however, is GPRS-specific equipment that by definition has to contain a number of specialized GPRS functions.)

Among these various interfaces with the GSM NSS, Gs is the most significant. When this interface is available, the GPRS network mode I will be available and using class B mobiles will be a trivial matter. However, the Gs interface is optional when the network mode is II or III, so paging coordination will be unavailable. This may force restrictions on the downlink data path for the mobile—keeping in mind that class B mobiles will likely constitute a significant portion of the initial terminal market thanks to better voice-data integration.

#### CONNECTING TO OTHER GPRS PLMNs

The inter-PLMN network will be constructed via connections among border gateways (BGs) belonging to different PLMNs. Operators can choose from four different PLMN interconnection strategies:

1. Directly connect BGs of different PLMNs.
2. Interconnect the BGs at a common network service point (NSP) owned and operated by the GSM Alliance.
3. Interconnect the BGs over a virtual private network (VPN) using a backbone provider's link layer network.
4. Interconnect the BGs over a VPN using the Internet.

**Strategy 1: Direct BG-BG Connections**

With strategy 1, the BGs need to be connected via PPP or frame relay over a T1 connection. The T1 can be used non-channelized, channelized into 56 Kbps channels, or in fractional mode. Support for single-link PPP is required, and support for multi-link PPP is desirable as well. Frame relay must support permanent virtual circuits (PVCs), with optional support for switched virtual circuits (SVCs). In addition, the frame relay unit must be able to act both in data terminating equipment (DTE) and data communications equipment (DCE) modes.

The biggest advantage of this strategy is the opportunity for progressive build-up of the interconnection network. The primary disadvantage will appear when a large number of PLMNs are connected in a full mesh, creating a prohibitive number of direct links.

**Strategy 2: Network Service Point**

With strategy 2, BGs are connected via 100BaseT Ethernet; support for Gigabit Ethernet is highly desirable as well. The interconnection between the GGSNs and the BG will most likely be point-to-point. Consequently, the BGs must support the interfaces described for strategy 1.

The biggest advantage of this strategy is the chance to share at least some of the costs involved in building an inter-PLMN network.

When an entity such as GSM Alliance operates the NSP, the quality can also be assured. On the other hand, building a full-fledged NSP when there are only a few early adopters of the technology may be unattractive for the PLMNs involved. Another potential problem could be the need for building multiple NSPs driven by geography or fault-tolerancy requirements.

### Strategy 3: VPN via the Backbone Provider's Link Layer

With strategy 3, BGs are connected to the backbone provider's network via frame relay over T1 or ATM over SONET. The T1 can be used non-channelized, channelized into 56 Kbps channels, or in fractional mode. The frame relay implementation must support PVCs (support for SVCs is again optional), and the frame relay unit must be able to act in DTE mode. The Internet Protocol (IP) should be carried over AAL5 as defined in RFC-2225 or as defined in RFC 1577. ATM PVC support is also required, although SVC support is optional. The ATM interface should be configured as UNI DTE. The physical layer must be SONET STC3c with either an electrical, coaxial cable interface or a single or multimode fiber-optic interface.

The biggest advantage of this strategy is the ability to offload the difficulties of interconnecting and operating the inter-PLMN network. Since the backbone provider is responsible for each PLMN's interconnectivity, there is no need for an inter-PLMN operator entity dedicated to the operation of such a network. Most of these services will be provided by the backbone provider. A disadvantage of this strategy is the potential cost, particularly if the backbone provider perceives this VPN as a service beyond the underlying link layer connectivity, in which case PLMNs may be required to pay a significant premium for this service. Another potential problem could be synchronizing the growth of the inter-PLMN VPN with the plans of the backbone provider.

### Strategy 4: VPN via the Internet

With strategy 4, a BG is connected to the Internet through one or more ISPs. These one-to-one connections can be over point-to-point links, over an NSP or over a backbone provider's link layer network. Depending on this interconnection strategy, one of the transport methods described above can be selected. (Note, however, that this strategy makes the use of the security protocol IPSec among BGs mandatory, whereas it may be considered optional for other strategies.)

The biggest advantage of this strategy is the ability to build various topologies easily. Each BG can be connected to multiple ISPs, creating multiple routes between each BG pair. The interconnectivity to an ISP is expected to be significantly cheaper than the cost of the service provided by the link layer VPN provider. The major disadvantage is the lack of QoS guarantees in today's Internet. Even though connections to multiple ISPs provide alternate paths, there is always the chance of significant degradation in the end-to-end QoS.

## CONNECTING TO EXTERNAL DATA NETWORKS

There are a number of interconnectivity challenges when considering the links between GPRS PLMNs and an external network such as an ISP or a corporate network. An operator will face different technical issues depending on which of two basic business models is chosen:

- **Model A: Wireless access provider.** The GPRS PLMN operator takes a passive stance toward managing the IP address space for its subscribers. In this model, the addresses are allocated by the connected ISPs and corporate networks.
- **Model B: Integrated voice/data provider.** The GPRS PLMN operator actively manages the IP address space for its subscribers. In this model, the static and dynamic addresses are allocated by the PLMN.

A third option would be to combine both business models, in which case an operator needs to consider both sets of technical issues.

### Business Model A: Wireless Access Provider

This scenario results in the PLMN being a pure access network used to extend the reach of an ISP or a corporate network (Figure 2). In this scenario, IP addresses are allocated by the subscribed ISP or the corporate network. In case of roaming, the subscriber can use a GGSN in the visited PLMN provided that there is connectivity between the visited PLMN and the ISP. If this can be guaranteed, there is no need for the Gp interface. However, we don't anticipate that this connectivity will always be available. Therefore, interconnectivity between PLMNs via the Gp interface is still necessary.

This business model has the advantage of relieving the PLMN operator from the burdens of providing total Internet access service. The obvious disadvantage is not being able to provide integrated services.

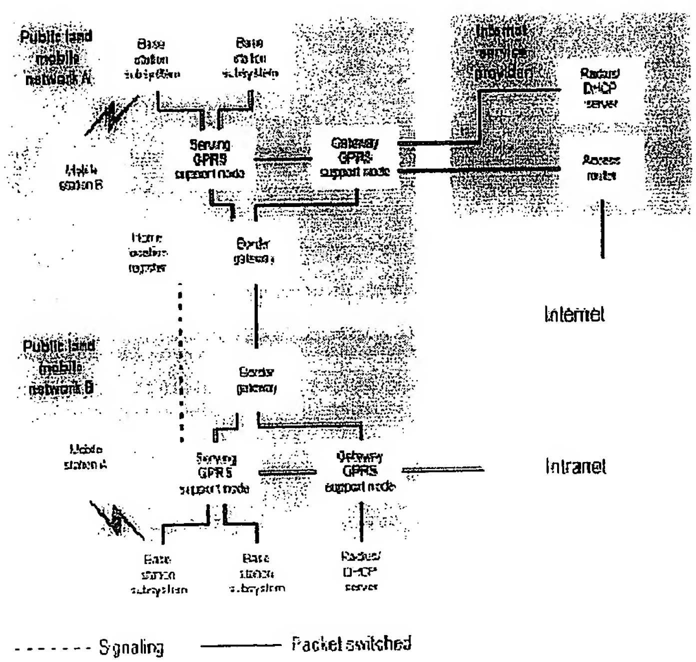


*Figure 2: GPRS configuration based on the wireless access business model.*

*Connecting with ISPs*

In this wireless access model, the PLMN becomes an extension of external networks. Address space is managed by the ISP, who also administers the addresses provided via dynamic addressing. In this model, the interconnectivity is based on pure tunneling and one-to-one connections between the PLMN and connected ISPs. Roaming will require the use of the home GGSN if the ISP does not have direct connectivity to the visited PLMN.



23

65

*Connecting to Corporate Networks*
Connecting to corporate networks with this business model will require dedicated connections. A link layer VPN can be built over the GPRS and frame relay or ATM connections between the subscriber and the corporate network.

*Connecting PLMNs for MS-MS Traffic*
As with ISPs and corporate networks, the model of interconnection among GPRS PLMNs for MS-MS traffic depends on the business model. In the wireless access provider model, there is no need for interconnectivity between the PLMNs for MS-MS traffic, since routing is handled by the existing peering and client-provider relationships among ISPs and/or corporate networks. In fact, this model doesn't require any special treatment at all for MS-MS traffic.

**Business Model B: Integrated Voice/Internet Provider**

This business model creates a "wireless ISP" whose subscribers can obtain their IP addresses from their home GGSN (Figure 3). The biggest advantage of this model is its strategic implications, since the PLMN operator can provide integrated voice and Internet services.

In order to provide ubiquitous coverage for roaming subscribers, interconnectivity between PLMNs via the Gp interface is a necessity. A roaming MS is always required to use its home GGSN. This simplifies security provisions, but the obvious disadvantage is the use of the home GGSN even when communicating with IP hosts nearby. This can be a significant issue when global roaming is considered. (Independent of roaming capability, PLMNs will be connected to the global Internet or corporate intranets through their BGs. A PLMN can also be deployed for pure local coverage, which does not require any interconnectivity with other PLMNs.)





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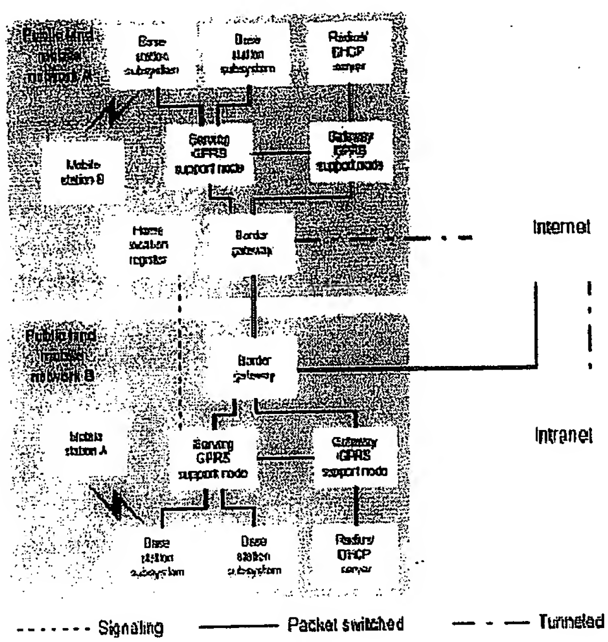


*Figure 3: GPRS configuration based on the wireless ISP business model*

*Connecting with ISPs*
With this business model, in which the GPRS PLMN operator is acting as an integrated voice/Internet provider, the PLMN and other ISPs are likely to have client-provider relationships or peering relationships. The client-provider relationship is more likely during the early stages of PLMN deployment, considering the limited subscriber base. However, with an increasing number of subscribers and resulting network traffic, peering relationships are more appropriate. In this case, the PLMN can be connected to a number of ISPs at a regional exchange point or can be directly connected via one-to-one connections. The PLMN functions as a regular autonomous system (AS), administering its own address space and interconnectivity. The typical inter-AS routing policy tools, such as Border Gateway Protocol (BGP), will be used to manage the interconnectivity.

*Connecting with Corporate Networks*
Interconnectivity with corporate network can be accomplished via IP-level tunneling. In this model, a subscriber-initiated tunneling protocol such as PPTP virtual dial-up or pure IPSec tunneling can be adequate for corporate connectivity. There is no need for one-to-one connection between the corporate network and the PLMN.



29

61

### *Connecting PLMNs for MS-MS traffic*

As mentioned above, when the PLMNs operate as wireless ISPs, they can establish client-provider or peering relationships. These wireless ISPs can exchange their traffic at one or more jointly established NSPs. Another alternative may be to contract a backbone provider, which forms the next level of hierarchy. In either case, we anticipate that MS-MS traffic will eventually become a significant portion of the overall GPRS traffic, provided that enabling applications such as advanced messaging are available.

When the wireless ISPs get into peering relationships, the issue of accounting will become critical, since the operators will have to agree on a cost compensation model. No-fee, flat-fee or fees based on trunk capacity are the common models on the Internet today. In a pure best-effort network, these models can be readily adopted by the PLMN operators. On the other hand, when the quality of service demanded by the subscriber becomes a critical service issue, more involved cost compensation models, such as packet cost accounting and TCP session accounting, may be necessary.

## Interconnecting to a QoS-Enabled Internet

In today's best-effort only Internet, the quality of service provided to the subscriber is not under the provider's total control. Since packets traveling to and from the subscriber travel through a number of domains beyond the provider's reach, GPRS PLMN operators will not be able to increase the subscriber's delivered QoS by providing significantly higher QoS in their own networks. Therefore, the interconnectivity model selected by the wireless ISP will be totally dependent on the price.

When QoS is enabled across the Internet, the wireless ISP will be able to negotiate service contracts based on QoS. Service level agreements (SLAs) executed between the wireless ISP and its providers and/or peer domains will be legally binding documents, allowing the operator to engineer the network and interconnections to be able to deliver the QoS levels expected by subscribers.

The QoS-enabled Internet will become a reality only when the enabling technologies become prevalent. Today there are a number of competing technologies, such as link layer approaches and the integrated services and differentiated services frameworks. The link layer approaches based on the inherent abilities of frame relay and ATM cannot be internetworked easily with IP-level traffic classification and scheduling mechanisms. The integrated services framework is based on the use of reservation and keeping soft-state within the network. Unfortunately, this approach is not scalable enough to embrace the vast number of active sessions on the Internet. The differentiated services framework is scalable, thanks to the coarse quantization of QoS expected. However, since this framework lacks the mechanisms to negotiate the end-to-end service, delivered QoS will still depend on the level of engineering quality in domains other than the PLMN.

Given the uncertainties, it is clear that the GPRS PLMN must be versatile enough to let the operator react wherever QoS technology goes. This is crucial to keep in mind when making decisions about the capabilities of the NSS and the BSS.

## STEPPING INTO THE FUTURE

GPRS is a significant milestone in the evolution of GSM, and it presents a great opportunity for operators to expand service offerings and stay ahead of competing networks. An agile implementation that considers all the possible developments in market demand and technology adoption will provide important benefits for both the operator and the end user.

With our many years of experience in wireless network design and implementation, Omnipoint Technologies is available to assist GSM North American operators with the move to GPRS and other advanced services. We can provide independent advice on business models, network engineering, performance improvements and other key factors that affect the long-term success of our clients.

## GLOSSARY

| | |
|---|---|
| AAL | ATM Adaptation Layer |
| AS | Autonomous System |
| ATM | Asynchronous Transfer Mode |
| BG | Border Gateway |
| BGP | Border Gateway Protocol |
| BSC | Base Station Controller |
| BSS | Base Station Subsystem |
| BSSGP | BSS GPRS Protocol |
| CS | Circuit Switched |
| DCE | Data Circuit-terminating Equipment |
| DTE | Data Terminal Equipment |
| EDGE | Enhanceed Data rates for Global Evolution |
| GGSN | Gateway GPRS Support Node |
| GMSC | Gateway Mobile Switching Center |
| GPRS | General Packet Radio Service |
| GSM | Global System for Mobile communications |
| GTP | GPRS Tunneling Protocol |
| HLR | Home Location Register |
| HSCSD | High Speed Circuit Switched Data |
| IP | Internet Protocol |
| IPSec | IP Security |
| ISP | Internet Service Provider |
| MS | Mobile Station |
| MSC | Mobile Switching Center |
| NSP | Network Service Point |
| NSS | Network Switching Subsystem |
| PLMN | Public Land Mobile Network |
| PPP | Point-to-Point Protocol |
| PPTP | Point-to Point Tunneling Protocol |
| PVC | Permanent Virtual Circuit |
| QoS | Quality of Service |
| RFC | Request For Comment |
| SGSN | Serving GPRS Support Node |

| | |
|---|---|
| SLA | Service Level Agreement |
| SMS | Short Message Service |
| SONET | Synchronous Optical NETwork |
| SS7 | Signaling System no. 7 |
| SVC | Switched Virtual Circuit |
| TCP | Transmission Control Protocol |
| UNI | User Network Interface |
| VLR | Visiting Location Register |
| VPN | Virtual Private Network |

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30

12